MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2016/2017

EEE7256 – DEVICE PROCESSING AND FABRICATION

(ALL)

21 OCT 2016
9:00 a.m. - 12:00 p.m.
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 4 pages including cover page with 5 questions only.

2. Attempt **ALL FIVE** questions and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1 (25 marks)

(a) In Czochralski crystal-growth process, oxygen atoms can be incorporated into the melt and then contaminate the silicon ingot.

(i) Explain how oxygen contamination could happen during the growth process.

[4 marks]

(ii) Explain how magnetic confinement can be used to reduce the oxygen contamination problem.

[5 marks]

(iii) Suggest an alternative growth method to reduce the oxygen contamination.

[1 mark]

(b) In Czochralski growth process, a boron-doped silicon ingot can be produced by dipping a silicon seed on the surface of the silicon melt containing the boron atoms and then the seed is slowly pulled upward away from the melt. The concentration of boron at the top of the silicon ingot is 1×10^{18} cm^{-3} and the segregation coefficient for boron in silicon is 0.8. Calculate the concentration of boron if the wafer is taken from the position corresponding to 50% of the initial melt that has solidified.

[6 marks]

(c) Discuss the significance of the following features of the clean room which can realise highly clean air:

(i) Air pressure.

[3 marks]

(ii) Air shower.

[2 marks]

(iii) Double-door pass-through.

[4 marks]

Question 2 (20 marks)

(a) Mask aligner is used in the photo-lithography process in order to transfer the patterns on an optical mask onto a wafer during patterning process. Compare the advantages and drawbacks between **contact printing** and **proximity printing** mask aligners.

[6 marks]

(b) Describe briefly the **SEVEN** steps needed in the photolithography technique for transferring patterns from an optical mask onto a wafer.

[7×2=14 marks]

Continued.....

Question 3 (20 marks)

(a) In semiconductor industry, diffusion is the common method used to introduce dopants into semiconductor wafer owing to its much simple equipment setup as compared to that of the ion implanter.

(i) Sketch the solid-source diffusion system and label clearly all the important components of the system in your schematic diagram.

[4 marks]

(ii) Describe how boron atoms could be introduced into the silicon wafer in order to obtain a *p*-type silicon wafer using diffusion method.

[8×1=8 marks]

(b) A 20 Å thick, uniform boron-doped layer is grown on top of a silicon wafer. The doping concentration of this layer is 10^{19} cm^{-3}. In order to perform the drive in diffusion process, the wafer is sealed with a layer of silicon dioxide (SiO_2) to prevent any outdiffusion, and it is annealed for 45 min at 1100 °C. The pre-exponential factor of the diffusivity and the activation energy for boron in silicon are 0.037 cm^2s^{-1} and 3.46 eV, respectively.

(i) Calculate the boron concentration as a function of depth from the surface of the silicon wafer after the annealing process.

[5 marks]

(ii) Determine the depth where the concentration is 10^{14} cm^{-3}.

[3 marks]

Question 4 (20 marks)

(a) Metallisation is an important fabrication step that can be used to form metal contacts or interconnects on devices to link devices with the external electrical circuitry. **Figure Q4(a)** shows a silicon substrate deposited with aluminium (Al) contacts on top of the surface of the substrate.

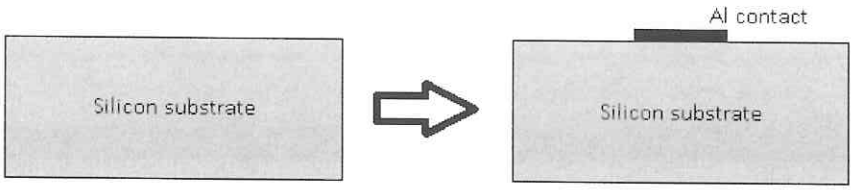

Figure Q4(a)

(i) With schematic diagrams, design and sketch the important steps required in the metallization of aluminium metal contacts following the lift-off process.

[8 marks]

Continued.....

(ii) If the metallisation in **Q4(a)** is deposited using the thermal evaporation method, step coverage problem might occur. What is step coverage problem?

[3 marks]

(iii) Suggest **TWO** methods to overcome the step coverage problem.

[3 marks]

(b) A 100 μm thick of *p*-type GaAs is to be deposited onto an *n*-type GaAs substrate to form an abrupt *p-n* junction. Justify whether molecular beam epitaxy (MBE) is suitable to be used for the deposition process.

[6 marks]

Question 5 (15 marks)

Solar cell made of crystalline silicon material is one of the suitable devices for the renewable energy harvesting technology as silicon solar cell is able to produce good efficiency. **Figure Q5** shows a fabricated crystalline *p-n* junction silicon solar cell from a silicon wafer. With suitable schematic diagrams, design the required fabrication processes to realise the solar cell. Label your schematic diagrams clearly and describe the fabrication process flow.

[15 marks]

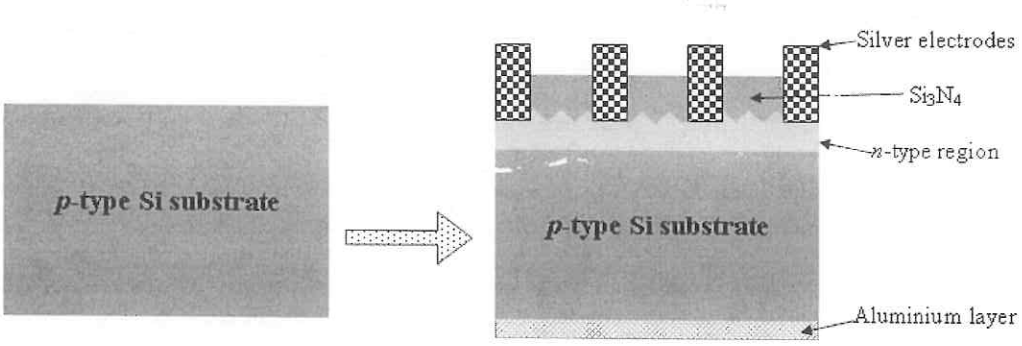

Figure Q5

List of constants

Electronic charge, $e = 1.602 \times 10^{-19}$ C
Boltzmann constant, $k_B = 1.381 \times 10^{-23}$ JK^{-1}
Avogadro number, $N_A = 6.02 \times 10^{23}$ atoms
Temperature in Kelvin [K] = x °C + 273
1 min = 60 s

End of Paper